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Geographic Contributions to Land-Use Planning

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In a number of the land use readjustment projects which have been undertaken by the United States Federal government under the "New Deal," geography has had considerable opportunity to demonstrate its methods and contributions among the technical branches applied in land use planning and administration. It is proposed here to inquire briefly as to the objectives set up, the methods used, and the results obtained, and, in particular, to suggest some of the elements of strength and weakness which have appeared. It seems probable, from recent experiences, that the geographer may perform an important function in this connection, and that a new and promising technical field is opening here. It should be worth while to raise the whole question of theory and training in geography, with the view of possible reorientation.

The most striking feature of the New Deal Operations in land-use planning, and in the development of projects, has been the effort to make use of technical services, in other words, to develop procedure on a scientific base. It has not been generally realized that other factors, especially social and political, may, and in many cases do, overshadow the technical in importance, and that seemingly sound technical advice often cannot be properly utilized because of these other factors. Nevertheless, the technical disciplines have had many opportunities to work, to experiment, and to report, and sufficient use has been made of their findings to provide a fairly adequate base for checking and analyzing the results.

THE SEVERAL APPROACHES TO LAND-USE PLANNING

In the broad problem of land use, as it has been attacked of late, several more or less scientific technical agencies have been involved. Among these

agencies are those dealing with specific and relatively narrow forms of land use, such as agriculture, forestry, recreation, or urban planning. These in turn may be split into various technical subdivisions. Other techniques not dealing with particular phases of land use, but rather each attacking a certain segment of the whole, include economics, sociology, history, political science, zoology, and botany. There is in this situation an obvious and serious problem of coordination, integration, and compilation, if such technical groups are to achieve the theoretical basis for land-use planning. This basis can be stated readily: land use planning should be developed on adequate base data—physical, economic, social and political. Theoretically it should be possible to turn over the essential segments to the several technical branches, to assemble and integrate the results, and to arrive at the answer or plan for the particular problem involved. Actually there are great difficulties in such a scheme, and at best only the broadest approximations to the ideal have been reached in a few cases. Some of the difficulties and some promising lines of approach may be reviewed through consideration of a few actual cases and areas.

Among the groups dealing with specific forms of land use such as agriculture or forestry, the weakness of approach as directed toward broad, balanced land-use planning, lies in an apparently inherent bias in favor of a particular type of use. For example, twenty years ago in the northern Lake States agricultural technology, through the agricultural colleges, was abetting the colonization companies in their high pressure efforts to expand agriculture. This condition was based on three assumptions: (1) that there could not be too much farm land, or too great production; (2) that agricultural technology could overcome any or all physical deficiencies in land; (3) that there were no other alternative uses of land worth consideration. All these assumptions have been proved erroneous, but they still persist in nearly all agricultural thought, and even where the errors are admitted the agricultural contingent avoids the issue, both unwilling and incompetent to reorient to the broader view.

In forestry the fundamental "saw-log" theory still dominates. In Michigan reforestation on a state basis began thirty years ago, on the very cull of poor lands accumulated through tax delinquency, and real though not admitted abandonment of such lands by the pro-agricultural group. The National Forest organization followed along the same lines. A similar set of basic assumptions to those of agriculture developed: (1) that there could not be too many saw-logs; (2) that any and all lands, not used agriculturally should become commercial forest lands; (3) that other than saw-log uses of non-agricultural lands were inconsequential. In spite of the lip-service now paid to other than forest uses of non-agricultural land by some foresters,

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the fundamental bias remains. It is true that now in a few instances these concepts are being challenged, as in Michigan, where the whole forestry program is being reconsidered with the view of possible fundamental reconstruction along lines of balanced land use. But it is to be noted that, in spite of an unusually tolerant attitude on the part of this forestry group, the impetus is coming from outside the professional group.

The recreational and wild-life utilization of wild lands naturally falls under the dominance of the National Parks Service. This organization is also dominated by certain fixed and fundamental concepts. The bias is illustrated by the moose problem on Isle Royale, an area tentatively allocated in 1931 to National Park dedication. Three technical branches reported on the starvation problem there present, checking closely; but the fundamental fear of the gun as the destroyer of wild life precluded any rational treatment of the facts by this group, in spite of the fact that in much of northern Michigan, wild life, as the basis of hunting, has constituted the most important land use of millions of acres for many years. Similar bias is illustrated in the predator control of the Biological Survey; also in its duck pond campaign.

The administrative phase of land-use readjustment illustrates the same narrowness of view and bias. In several cases where reasonably adequate data for full circle land-use adjustment have been provided and comprehensive experiments have been planned, the objectives and procedures have been narrowed to fit the use concepts of the particular bureau or organization in charge, and most other phases of the problem have been ignored. These remarks are not presented as adverse criticism, but simply to illustrate the difficulties inevitably present in the land-use readjustment problem. Such difficulties were recognized, of course, at the start, and the National Planning Board, (later the National Resources Board and still later the National Resources Committee), was set up primarily in the effort to integrate and coordinate research and administrative machinery towards the ends of concerted and effective effort. Its failure to do so successfully has been due in large part to the cumulative effects of these various factors which have been mentioned.

From the point of view of effective contribution to land-use planning, the academic branches generally are much less potent and useful than the land-use organizations mentioned above. In such disciplines as economics, history, sociology, or biology, there is the same narrowness of approach, and disinclination to accept and utilize the findings of the other groups, that is apparent in the land-use organizations. Further, the academic lines seldom in the past have been oriented at all toward research of the kind necessary to land-use planning. Few individuals or groups have been interested in

turning their efforts from the accustomed lines into the development of new techniques necessary for useful and acceptable land inventories. The theoretical ideal of cooperation between all the academic disciplines has failed of achievement because of lack of interest, lack of experience, and the apparently inevitable tendency toward narrow specialization.

With the operation of the New Deal land program, in its several phases, the fundamental concepts of land use planning are beginning to clarify. It is being recognized that planning consists, largely, of a discovery of the trends in land use within definite units of area, and in the effort to facilitate and direct these trends, rather than in an attempt to impose some pre-conceived order or pattern of use. The scientific basis of planning thus becomes the systematic study of areas, all of the critical facts and relationships within and between areas in their several phases—physical, economic, social and political. The basic concept of "land inventory" with its broad range of interest, is gradually coming to dominate the scene.

There are several disciplines which claim precedence in this field. The economist, in many cases, admits his preemptive position and technical capacity. In terms of the definition of his field he is correct; in terms of actual areal and regional study, in topographic detail, he is considerably in error. The small groups of economists actually engaged in the study of land-use problems over the last decade or two have not demonstrated an effective development of the essential techniques and concepts required. The sociologists are similarly ineffective in their approach to comprehensive regional analysis.

Like the economist and sociologist, the geographer lays claim to this particular field. If geographers are willing to include in their profession various individuals and groups hitherto not officially recognized, quite a good case can be made for geography in this connection. It remains, of course, to check the validity of the geographic concept and to indicate some of the necessary connections and relationships which must be involved. The various statements of the definition of geography which are in wide use today all agree on two points: (1) the necessity of focusing attention on the region or area as a unit of investigation, and (2) in the inclusion of a very wide group of phenomena—physical, economic and social—in so far as they are associated within the areal complex. In theory many of the regional studies made by geographers during the past twelve years should approach closely the ideal of "adequate base data" for land-use planning. It does not seem particularly important at the moment whether the theoretical ideal has been achieved or not, nor that, through its method of approach to land-use problems over a considerable period, it may lay claim to a certain priority or vested interest in the field. The significant fact is that many geographers

through a considerable period of time have been thinking, speculating, and experimenting in the direction of regional land inventory in its broadest sense, and that most of the concepts involved, which seem unique and novel to the other disciplines, may at least be supposed to be familiar to geographers. The land inventory methods followed by geographers, both on an intensive and extensive basis, fit nicely into present fundamentals of the planning concept. Further, geographers always have attempted to discover trends in utilization, and frequently, in regional studies, have made efforts toward determination of the probable lines of expansion or contraction, growth or decline, thus following the planning procedure closely.

CONTRIBUTIONS MADE BY THE GEOGRAPHIC APPROACH

A number of illustrations follow, taken from geographic efforts in Michigan, not because Michigan has been especially different from other areas, but because the writer is most familiar with this state, and finds in it sufficient evidence to illustrate several apparently significant points.

In 1920 an academic group, representing the major institutions and disciplines, began a series of discussions of the land-use problem of northern Michigan. It was recognized that a serious "problem area" had developed—that the standard utilizations of land had declined or disappeared, and that potential use values were being dissipated through the failure of the standard economic, social, and political processes to function. It was felt that "something ought to be done about it," and the customary formula of "let's make a survey" followed naturally. It was concluded that if the essential facts were known, certain abuses might be abated or prevented, and lines of proper development activity might be instituted.

This action led ultimately to the establishment of the "Michigan Land Economic Survey." Two conditions of this original concept are significant. First, an attempt was made to represent in the group which planned the procedure, and also in the actual field personnel, all agencies capable of contributing to the objective of a complete inventory; thus agricultural specialists, foresters, biologists, geologists, soil scientists, and economists, as well as geographers, became involved. Second, the original inventory concept was proposed by a geographer (C. O. Sauer) and the specifications for the actual field work, a major part of the direction of that field work, and the compilation of results were in his hands. With such antecedents, and with a fortunate selection of later directing personnel of unusual geographical competence, it is not surprising that this agency has gained the reputation of being a striking illustration of the application of an essentially geographic procedure, in spite of its rather misleading official name.

The original concept of a group of specialists representing all pertinent

fields of investigation was never realized. The economists either were not interested or questioned the necessity of such detailed inventory. The biological group failed to function, not being equipped for or much interested in such quantitative inventory procedure. But on the whole, the geographical objective was approximated to a degree which could not be equalled by the efforts of any individual geographer.

It was assumed at the start that land inventory, the construction of maps, and the compilation of data, was the only essential, and that land-use planning and readjustment would somehow follow, carried out by agencies later to be set up and designated. In certain respects matters have worked out that way. The Survey of Roscommon County, in 1923 the poorest in the State, demonstrated that there was no potential agricultural land available beyond that already in use; that tax delinquency was steadily forcing much of the low quality land into public ownership; and that the recreational industry, centering about the lakes, was growing rapidly, creating large values, and providing markets for certain limited agricultural areas adjacent. The Conservation Department in charge of State lands was thus able to anticipate expanding public ownership and to adjust its state forest, game preserves, and public hunting ground utilizations to these conditions and to regulate hunting and fishing in such manner as to provide a certain stimulation to the recreational developments.

Much of the land-use planning for public lands in northern Michigan has been based upon the Land Economic Survey inventories or upon other similar work carried out in special problem areas. The geographic concept has been utilized in the several special types of inventory involved in present game management procedures, with rapidly developing technique in problems of zoogeography. The significant part which land inventory must play in the classification of land for rural zoning purposes,[1] is suggested in laws recently passed in several States, and in considerable local interest in zoning problems. Thus there is much evidence to indicate that the idea of land inventory, as fundamental to land-use planning, had functioned quite effectively, and had been widely accepted in Michigan prior to the development of the New Deal land programs. This had occurred without any effort to erect a systematic hierarchy of bureaus involving the technical, economic, social, and political organization of the State in any definite land-use plan. The procedure involved a program of public education, and the adoption of measures to accelerate the trends in land use definitely identified through the inventories.

[1] Schoenmann, L. R.: "Land Inventory For Rural Planning in Alger County, Michigan," *Papers of the Michigan Academy of Science, Arts, and Letters*, Vol. 16, 1931 (1932), pp. 329–361.

With the advent of the Federal land program, at first only a scheme for the reduction of sub-marginal land, it was relatively easy to designate certain problem areas, and to work out definite plans for their experimental treatment. A project for removal of scattered farms on poor soils in a large area of northern Michigan was organized almost wholly on the basis of the Land Economic Survey inventories, and the rededication of these lands to forestry and recreational use was readily accepted. In southern Michigan several smaller projects were based on geographical inventory.

It is by no means to be supposed that the procedure in land use adjustment has been solved in these cases, for the questions of administrative procedure and the discovery of what is socially and politically feasible and practicable still resist solution most stubbornly. But on the whole a reasonably satisfactory job of technical inventory and planning has been accomplished, on an unusually sound basis. On the negative side, which is equally important, the intimate knowledge of conditions provided by the inventories has made it possible to prove the unsoundness of many proposed projects, and to prevent the imposition of experiments bound to fail under the factors present.

From the point of view of the "science" of geography, these experiences of the past and especially of the last two years, here only touched upon, represent accomplishments of the geographical point of view, rather than successful efforts of individual geographers or any group of geographers. In this geographic point of view, as applied to land inventory and land-use planning, so many items are involved, and such accuracy of results is demanded, that no individual geographer can ever acquire the technical background necessary to carry out the work himself. To be effective in this field he must either confine his efforts to some special and narrow phase of the geographical field in which he can acquire the necessary competence, or ally himself with other scientists and technicians and together with them build up the essential comprehensive body of data needed. This is not merely a function of the synthesist, taking over the work of others and compiling a complete areal or regional report. Much of the work of the other disciplnes, especially economics, sociology and biology, has had little of the geographic point of view, and hence little geographic significance. The geographer cannot use most such work, however well done it may be from some other point of view. Often he must undertake the exploratory work himself. There is enough such work to be done to busy a great many competent geographers for some time to come. The Michigan geographical group which has functioned through so many years, and the technical committee which has supervised many of the New Deal operations, is conspicuous for the paucity of professional geographers in its membership.

The results which have been attained are the results of an essentially geographic point of view generated with the establishment of the Land Economic Survey fifteen years ago, the application of this point of view to other and various fields, and the harmonious cooperation between disciplines which it has made possible.

From the evidence here brought out, and from many other similar sources which might be mentioned, it seems quite clear that geography has demonstrated its fundamental usefulness in this field. If land-use planning continues, and there is every reason to believe that it will under one name or another, some group certainly will ultimately dominate this field. It probably is not important whether it goes by the name of geography, but it does seem important that geographers as a group recognize the possibilities, and choose whether to reorient themselves, where individually inclined, in both training and objectives. Certainly a broader base in early training than that now common, will be required. There are too many totally blind spots in the technical training of most geographers to allow them even to approximate their theoretical pretensions. In order to develop the minimum degree of technical competence which is required for the necessary work, the field training of geographers will need to be expanded to many times its present average offerings in geography departments. No other science pretends to produce competent technicians with so small a percentage of laboratory time. The most difficult hurdle will be the necessity of long, intensive and unremitting study by individuals in relatively small regions. There seems to be no other way of acquiring the broad basic knowledge which this work requires, nor of making the intimate contacts with workers in other fields which are necessary in fulfilling the geographical ideal as applied to these problems. It will be necessary in most cases to choose between the very attractive and admittedly valuable types of work which have largely characterized geography in the past, and a different and certainly less romantic approach. It does not seem probable to the writer that a concerted rush of geographers into this field is to be predicted.

University of Michigan,
March, 1936.

The Unit Area Method of Land Classification*

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A MAJOR PROBLEM IN GEOGRAPHIC FIELD INVESTIGATION

Today a major problem in geographic field investigation is the development of techniques that bridge the gap between methods of detailed field analysis and methods of reconnaissance. The need for a solution for this problem, already acute from the standpoint of scientific research, is made particularly acute by the requirements of the land utilization or planning programs launched in recent years.

The scientific and the practical requirements of research and land planning that the needed techniques must satisfy are very similar. Both are concerned with actuality. The portrayal of this actuality, in so far as possible, is, therefore, of first moment. This portrayal must be quantitative, and it must be as nearly accurate as possible. It need be no more detailed than the demands of the research or planning it is to serve. At the same time, it must not be more generalized than these demands. From a practical standpoint, the portrayal must be available when it is needed and its cost must be commensurate with its utility.

Notable steps have been made in the development of techniques that satisfy these research and planning requirements. Included are the development of the fractional-code and other methods of detailed field analysis, a wide variety of traverses, and detailed analyses of sample areas—both selective and random. All these developments are valuable to research and planning and meet one or another of the requirements mentioned. Methods of detailed analysis provide accurate, quantitative data. But they fail when applied to large areas due to the great amounts of time and cost involved. Methods employing traverses and sample areas are saving of both time and expense, but the accuracy of the interpolated results is open to considerable doubt. Thus none of these techniques fully satisfies the double requirement of accuracy and practicality.

The unit area method of land classification as developed by the Land Classification Section of the Tennessee Valley Authority represents an attempt to achieve the greatest possible accuracy in field investigation within certain practical considerations of time and cost. As such, it is an attempted solution of the problem discussed above. This method is essentially an

* Invited paper delivered before the Association at St. Louis, December, 1935.

adaptation of the fractional-code method.[1] Its unique qualities are the application of fractional-code notations to land units of not less than 200 acres, the use of aerial photographic mosaics as base maps, and a consideration of those items best calculated to serve land planning. Like all geographic field methods, it attempts an accurate quantitative portrayal of the occupance pattern. It was developed to perform this function particularly for the Tennessee River Basin.[2]

FACTORS CONTRIBUTING TO THE DEVELOPMENT OF THE UNIT AREA METHOD

The development of the unit area method was predicated on the availability of the fractional-code and several sampling methods. Three other major factors contributed. These were:

a. a considerable amount of detailed field work;
b. the availability of aerial mosaics; and
c. the opportunity to conduct operations on a relatively large scale.

[1] *Editor's note.*—The evolution of fractional notation on field maps began with a field conference of ten mid-western geographers in the spring of 1925. The sample of land occupance mapped by this group may be seen in the issue of these *Annals* for September, 1925 (Wellington D. Jones and Vernor C. Finch, "Detailed Field Mapping of an Agricultural Area," vol. 15, pp. 148–157). Subsequent publications on field methods are cited to 1927 by Derwent Whittlesey, "Devices for Accumulating Geographic Data in the Field," *Annals,* vol. 17 (1927), pp. 72–78. The most recent and complete specimen of the method of fractional notation as applied laboriously to a rural area is Vernor C. Finch, "Montfort—A Study in Landscape Types in Southwestern Wisconsin" (*The Geographical Society of Chicago, Bulletin No. 9,* University of Chicago Press, 1933). Dr. Hudson himself devised a means of covering territory more expeditiously, but still quantitatively, by using automobile and crop-frontage meter. See his dissertation, *Augusta County, Virginia—A Study of Patterns,* in The University of Chicago Libraries. It was left for Dr. Hudson and his coworkers of the TVA to combine various geographic field techniques and to bring them within the limits of practicability.

The historical background of land classification and its relation to land planning in the United States is treated by Chas. C. Colby, "Changing Currents of Geographic Thought in America," which appeared in the preceding number of these *Annals* (vol. 26 (1936), pp. 1–38). See especially the section "Phases of the Planning Process," pp. 31–35.

[2] The Land Classification Section (formerly the Geography Section) is one of five sections in the Division of Land Planning and Housing. The other sections are: Town Planning, Architectural, Recreation and Conservation, and Service and Drafting. All the members of the Section contributed directly or indirectly to the development of the unit area method. Particular recognition is due E. S. Draper, Director, Division of Land Planning and Housing; C. C. Colby, Consultant to the Division; C. A. Mooers, Director, Tennessee State Agricultural Experiment Station; Malcolm J. Proudfoot, Bernard H. Schockel, and Robert M. Glendinning, Associate Geographers; and Harold V. Miller, Assistant Geographer.

Detailed Work.—Detailed field studies were made over an aggregate of approximately 550 square miles in three widely separated and distinctly different areas in the Tennessee River Basin. These studies employed the fractional-code method, combining it for the first time on a large scale with the use of aerial mosaics as base maps.[3] In addition to serving the specific purposes for which they were made, these studies performed three very vital functions relative to the unit area method. First, they revealed that the data they provided were unnecessarily detailed for the first steps in Valley-wide planning and that on a Valley-wide basis the methods they employed moved too slowly and were too expensive.[4] Second, they indicated the more significant items that should be retained in a rapidly moving Valley-wide program of field work. And third, they developed a field personnel intimate with conditions in the Basin, well trained in field techniques, and skilled in the use of mosaics.

Aerial Mosaics.—Aerial mosaics are of value in field mapping primarily in terms of the speed and accuracy they make possible. First, they provide a superabundance of orientation points and a large body of information that can be read directly from the photographs; and second, they provide a considerable amount of valuable data that do not have to be recorded in the field. Since speed coupled with accuracy is an inherent quality of the unit area method, mosaics are thus essential to its effective application.

Large-Scale Operations.—The opportunity to conduct operations on a relatively large scale permitted the training of a highly skilled field personnel and made possible the extensive application and testing of field methods under a wide variety of circumstances.[5]

METHODS AND PRODUCTS OF THE UNIT AREA METHOD

Types of Land Recognized.—In the present application of the unit area method six major types of land are recognized: namely,

[3] These mosaics were on the scale of 1 : 12,000. They were printed on heavy-duty paper with a matte finish. The digits in the numerator were concerned with cropped land, pasture land, woodland, idle land, farmsteads, rural commercial establishments, and recreational areas. The digits in the denominator were concerned with slopes, drainage, erosion, rock exposure, stoniness of soils, and soil types.

[4] Where the landscape was not complex and where working conditions were favorable, roughly 400 acres could be covered per man day. The total cost of producing a "master" mosaic, one to which all field data are transferred in ink, was approximately $25.00 per square mile.

[5] It should be noted, also, that ample facilities were available and that the Land Classification Section operated with a free hand in spite of the fact that the applications of geographic techniques to the practical problems of land planning were largely experimental.

TABLE I

The Major Land Uses or *Human* Items on the Basis of which Homogeneous Land Use are Delimited. Noted on the mosaics and maps by the digits in the numerator of the long fraction. See Figure 1 as a sample of how the symbols appear on the maps

First Digit	*Second Digit*	*Third Digit*	*Fourth Digit*	*Fifth Digit*
Major Land Use	Agricultural Emphasis	Field Size	Amount of Idle Land	Quality of Farmsteads and Equipment
1. General farming	A. Corn	1. Large	1. Little idle land	1. Excellent
2. Animal industry	G. Grain (small)	2. Medium	2. Limited idle land	2. Good
3. Cash crop farming	B. Beef cattle	3. Small	3. Considerable idle	3. Medium
4. Part-time farming	D. Dairying	4. Very small	4. Excessive idle	4. Poor
5. Subsistence farming	S. Sheep			5. Very poor
6. Forest land	H. Hogs			
7. Recreational area	M. Mules and/or horses			
8. Rural village area	P. Poultry			
9. Urban area	T. Tobacco			
0. Manufacturing and mining areas	C. Cotton			
	W. Truck			
	O. Orchard			
	N. No emphasis			
	F. Forage			

a. agricultural land;
b. forest land;
c. land used for recreation;
d. land occupied by rural settlements and villages;
e. land occupied by urban developments; and
f. land occupied by manufactural and mining enterprises.[6]

As a preliminary to more detailed study the last four types are delimited and noted on the field mosaics only by a single distinguishing Arabic numeral, **7**, **8**, **9**, and **0**, respectively (Table I and Fig. 1). Outside of urban districts, recreation, manufacturing, and mining are not, as yet, of major areal or economic significance. A treatment of rural villages and urban areas on the scale of operations adopted would not yield data in sufficient detail to be significant.

Forest Land.—Forest areas are delimited and identified on the mosaics by the numeral **6** in the numerator of what is called a "*long* fraction" (Table I and Fig. 1). These areas are classified into units of 200 acres or more on the basis of the physical conditions of the land, each represented by a digit in the denominator of the long fraction noted above. The items noted are slope, drainage, erosion, stoniness of soil, rock exposure, soil depth, and soil fertility (Table II and Fig. 1). Forest land is not classified on the basis of forest types, because matters of this nature are adequately cared for by the Forestry Division of the Authority.

Agricultural Land.—The major portion of the Basin is occupied by land in farms. More people in the Basin are employed in agriculture than in any other occupation. Furthermore, the more pressing problems in the Basin originate in rural areas and are related to the agricultural use of land resources. For these reasons, it is appropriate that the major emphasis of the present undertaking is on agricultural land.

In the field analysis of agricultural land, five sets of conditions are mapped. First, as with the forested areas, the land is classified on the basis of slope, drainage, erosion, stoniness of soil, rock exposure, soil depth, and soil fertility (Table II). These features are recorded on the mosaics in the denominator of the long fraction (Fig. 1). There are, of course, as many classes of land as there are types of units delimited. Second, the land is classified on the basis of major cultural features: namely, major agricultural land use, agricultural emphasis, field size, amount of idle land, and quality of farmsteads and equipment (Table I). Each of these items is recorded in the numerator of the long fraction (Fig. 1). Here are, again,

[6] It should be noted throughout this discussion that if the unit area method were applied to conditions unlike those of the Tennessee River Basin or for purposes differing from those of the present undertakings, modifications could and should be made to meet these conditions and purposes.

TABLE II

The Major Physical Conditions of the Land on the Basis of which Homogeneous Units are Delimited. Noted on the mosaics and maps by the digits in the denominator of the long fraction. See Figure 1

First Digit	*Second Digit*	*Third Digit*	*Fourth Digit*
Slope	Drainage	Erosion	Stoniness
1. Relatively level	1. Thorough	1. Little or no observable erosion	1. Free from stones
2. Relatively level to undulating	2. Adequate	2. Little denudation by erosion	2. Moderately stony
3. Undulating to moderately hilly	3. Poor	3. Sheet erosion and ephemeral gullies	3. Stony
4. Hilly	4. Very poor	4. Excessive sheet erosion and gullying	4. Very stony
5. Steep	5. Excessive	5. Excessive gully erosion	

Fifth Digit	*Sixth Digit*	*Seventh Digit*
Rock Exposure	Soil Depth	Soil Fertility
1. Little or no rock exposure	1. Deep (6 feet or more)	1. Exceptionally fertile
2. Limited rock exposure	2. Moderately deep (3 to 6 feet)	2. Fertile
3. Considerable rock exposure	3. Shallow (1 to 3 feet)	3. Moderately fertile
4. Excessive rock exposure	4. Very shallow (less than 1 foot)	4. Low in fertility
5. Rock exposure barren		5. Very low in fertility

as many classes of land as there are types of units delimited. Third, the land is appraised and classified in five categories on the basis of agricultural quality as indicated by the present physical conditions of the land (Table III).

TABLE III

The Five Classes of Land Classified on the Basis of the Agricultural Quality of the Present Physical Conditions of the Land
Noted on the Mosaics and Maps by the Denominator of the Short Fraction. See Figure 1

Class 1. Units of 200 acres or more that are characterized by the following physical indices, *appearing individually or in combination*: (1) relatively level or moderately undulating surface; (2) adequate or thorough drainage; (3) little or no observable erosion; (4) deep stone-free soil of exceptional fertility; and (5) little or no rock exposure.

Class 2. Units of 200 acres or more that are characterized by the following physical indices, *appearing individually or in combination*: (1) relatively level to undulating surface; (2) adequate or thorough drainage; (3) little denudation by erosion; (4) deep fertile soils, free from stone; and (5) limited rock exposure.

Class 3. Units of 200 acres or more that are characterized by the following physical indices, *appearing individually or in combination*: (1) undulating to moderately hilly surface; (2) adequate or thorough drainage; (3) denudation by sheet erosion or moderate gullying to a stage at which erosion control is economically feasible; (4) soils of moderate fertility and stoniness; and (5) limited rock exposure.

Class 4. Units of 200 acres or more that are characterized by the following physical indices, *appearing individually or in combinaiton*: (1) hilly surface; (2) poor or excessive drainage; (3) denudation by sheet erosion or gully erosion to a depth that renders cultivation difficult and to a stage that further tillage would result in deterioration beyond a point of economically feasible rehabilitation for pasture purposes; (4) shallow or stony soils, low in fertility; and (5) considerable rock exposure.

Class 5. Units of 200 acres or more that are characterized by the following physical indices, *appearing individually or in combination*: (1) steep slopes; (2) very poor or excessive drainage; (3) denudation by sheet or gully erosion beyond the point of cultivation and economically feasible rehabilitation other than by reforestation; (4) shallow or stony soils, very low in fertility; and (5) excessive rock exposure.

These five classes are noted by numerals from **1** to **5** in the denominator of the "*short* fraction," which stands as a prefix to the "*long* fraction" referred to above (Fig. 1). This numeral represents the judgment of the field man based on all observable physical factors, whether they have been recorded or not. Fourth, the land is appraised and classified in five categories on the basis of the effectiveness of the present agricultural use of the land and the economic conditions of the people (Table IV). These classes are noted by

TABLE IV

The Five Classes of Land Classified on the Basis of the Quality of the Present Agricultural Use of the Land
Noted on the Mosaics and Maps by the Numerator of the Short Fraction.
See Figure 1

Class 1. Units of 200 acres or more that are characterized by the following use indices, *appearing individually or in combination*: (1) medium and/or large uninterrupted fields; (2) fields free from weedy or brushy cover; (3) little or no idle land; (4) excellent farmsteads and farm equipment; and (5) any other evidence of an excellent standard of living.

Class 2. Units of 200 acres or more that are characterized by the following use indices, *appearing individually or in combination*: (1) medium and/or large uninterrupted fields; (2) fields largely free from weedy or brushy cover; (3) little or no idle land; (4) good farmsteads and farm equipment; and (5) any other evidence of a good standard of living.

Class 3. Units of 200 acres or more that are characterized by the following use indices, *appearing individually or in combination*: (1) small and/or medium uninterrupted fields; (2) limited weedy or brushy field cover; (3) considerable idle land; (4) medium quality farmsteads and farm equipment; and (5) any other evidence of a medium quality standard of living.

Class 4. Units of 200 acres or more that are characterized by the following use indices, *appearing individually or in combinatino*: (1) small and/or interrupted fields; (2) heavy weedy or brushy cover; (3) considerable idle land; (4) poor farmsteads, farm equipment; and (5) any other evidence of a moderately low standard of living.

Class 5. Units of 200 acres or more that are characterized by the following use indices, *appearing individually or in combination*: (1) very small and/or interrupted fields; (2) sparse weedy or brushy field cover; (3) excessive amounts of idle land; (4) very poor farmsteads and farm equipment; and (5) any other evidence of a very low standard of living.

numerals from 1 to 5 in the numerator of the short fraction (Fig. 1). This numeral signifies the judgment of the field man based on any pertinent observable data whether recorded or not. Finally, the land is appraised and classified in five categories according to the relative severity or absence of problems and needs for readjustments (Table V). These classes are

TABLE V

The Five Classes of Land Classified on the Basis of the Economic Status of the People and the Physical Conditions of the Land[1]

Noted on the Mosaics and Maps by Roman Numerals. See Figure 1.

Class I.—Units in which no significant agricultural problems are apparent. These units are characterized by an excellent standard of living and by land that is exceptionally well suited for both general and specialized types of agriculture. The first is indicated by the following indices, appearing individually or in combination: (1) medium and/or large uninterrupted fields; (2) fields free from weedy and/or brushy covers; (3) little or no idle land; (4) excellent farmsteads and farm equipment; and (5) other evidence of an excellent standard of living. The second is indicated by the following indices, appearing individually or in combination: (1) relatively level or moderately undulating surface; (2) adequate or thorough drainage; (3) little or no observable erosion; (4) deep stone-free soil of exceptional fertility; and (5) little or no rock exposure.

Class II.—Units in which the apparent agricultural problems are not critical. These problems, in most cases, can be solved readily by programs of education and demonstation. These units are characterized by a good standard of living and by land that is well suited for both general and specialized types of agriculture. The first is indicated by the following indices, appearing individually or in combination: (1) medium and/or large uninterrupted fields; (2) fields free from weedy or brushy covers; (3) little or no idle land; (4) good farmsteads and farm equipment; and (5) other evidence of a good standard of living. The second is indicated by the following indices, appearing individually or in combination: (1) relatively level to

[1] The definitions appearing here were formulated on the basis of work done in the Upper Tennessee Valley. As the work progresses into new areas, these definitions are being recast to include conditions typical of the new areas, the object being to develop a classification based on valley-wide conditions. To June 1, 1936, roughly 10,000 square miles have been covered in the Upper Tennessee Valley and 6,000 square miles immediately east of Florence, Alabama.

undulating surface; (2) adequate or thorough drainage; (3) little denudation by erosion; (4) deep fertile soils, free from stone; and (5) limited rock exposure.

Class III.—Units in which agricultural problems are moderately critical. These problems, in most cases, can be solved by intensive programs of education and demonstration. These units are characterized by a medium standard of living and by land that can be used for general and for special crops under proper management. The first is indicated by the following indices, appearing individually or in combination: (1) small and/or medium uninterrupted fields; (2) limited weedy or brushy covers; (3) considerable idle land; (4) medium quality farmsteads and farm equipment; and (5) other evidence of a medium quality standard of living. The second is indicated by the following indices, appearing individually or in combination: (1) undulating to moderately hilly surface; (2) adequate or thorough drainage; (3) denudation by sheet erosion or moderate gullying to a stage at which erosion control is economically feasible; (4) soils of moderate fertility and stoniness; and (5) limited rock exposure.

Class IV.—Units in which agricultural problems are very critical. Some of these problems may be solved through intensive programs of education and demonstration, but most of them will require a marked readjustment and/or a reorientation of economic activities. These units are characterized by a moderately low standard of living and by land which is for the most part unsuited for cultivated crops. The first is indicated by the following indices, appearing individually or in combination: (1) small and/or interrupted fields; (2) heavy weedy or brushy covers; (3) considerable idle land; (4) poor farmsteads and farm equipment; and (5) other evidence of a moderately low standard of living. The second is indicated by the following indices, appearing individually or in combination: (1) hilly surface; (2) poor or excessive drainage; (3) denudation by sheet or gully erosion to a depth that renders cultivation difficult and to a stage that further tillage would result in deterioration beyond the point of economically feasible rehabilitation for pastoral purposes; (4) shallow or stony soils, low in fertility; and (5) considerable rock exposure.

Class V.—Units that, in most cases, are suitable only for forest use. Some areas may prove of value for recreation purposes, game preserves, etc.; some might be truly waste land. These units are characterized by a very low standard of living and land that is virtually in all cases unsuitable for agriculture. The first is indicated by the following indices, appearing individually or in combination: (1) very small and/or interrupted fields; (2) sparse weedy or brushy field covers; (3) excessive amounts of idle land; (4) very poor farmsteads and farm equipment; and (5) other evidence of a very low standard of living. The second is indicated by the following indices, appearing individually or in combination: (1) steep slopes; (2) very poor or excessive dranage; (3) denudation by sheet or gully erosion beyond the point of cultivation and economically feasible rehabilitation other than by reforestation; (4) shallow or stony soils, very low in fertility; and (5) excessive rock exposure.

noted on the mosaics by integral Roman numerals from **I** to **V**, inclusive (Fig. 1). In part, these Roman numerals represent a summary of their accompanying short and long fractions; but, again, the entire complex in all its pertinent observable respects is carefully considered and appraised before the field judgment is made.

Legends and Definitions.—The legends for the twelve digits in the long fraction alone contain sixty-nine items. Added to this are the fifteen items that are included in the short fraction and the Roman numerals. Because of the number and complexity of these eighty-four items, the development of the legends and definitions constituted in itself a major undertaking. In the first place, significant items had to be decided upon. Then, each item had to be so thoroughly analyzed and defined that each field man's work would be comparable to another's, and each item noted would mean the same thing, regardless of the area for which the notation was made. Thus,

many days—even weeks were spent in group conferences drawing upon the field experience of each man. Finally, no item or definition was adopted until it had been rigidly tested in the field and approved by the entire group.

Some definitions could be adopted in final form before work began because the items which they cover are constant and measurable. For example, "Relatively level land" was defined as "Land characterized by slopes of zero to 5 per cent grade." Other definitions were agreed upon, but have been left open for reexamination and retesting until enough examples will have been encountered to warrant establishing a classification which would apply to the entire Valley. For instance, the definition for "Good quality farmsteads and equipment" for one portion of the Basin is not applicable to all portions because the indices that distinguish quality of farmsteads and equipment are not the same over the entire area. The same holds for certain other items, particularly the five classes of land noted in the short fraction and in the Roman numeral. As each new condition is encountered it is noted; and as evidence is accumulated, definitions covering these items are reworked, agreed upon, and restated in such a manner that they are inclusive to date.

Field Materials and Procedures.—The mosaic used as base maps in the field are printed on heavy-duty paper with matte finish, scale 1 : 24,000 (Fig. 1). Disregarding overlap, each covers an area of 120 square miles. These mosaics are indexed according to an established system so that they can be properly recorded and filed after the field work is completed. Each mosaic is cut into three equal parts for field use. Clinometers, soil augers, and cars complete the field equipment.

In rough outline, the steps in the field procedure are as follows:

a. the recognition of an essentially homogeneous land unit;
b. a tentative characterization of the unit is made and recorded on the mosaic in the form of a long fraction;
c. a careful examination is made of the mosaic, and tentative boundaries of the unit are drawn;
d. the boundaries tentatively drawn are checked and corrected at every point to which access is possible by roads, either immediately or when adjacent areas are being covered;
e. a final long fraction is recorded; and
f. final judgments for the three summary classifications are made.

When a field sheet has been completed, pencilled notations are inked in, mosaics are checked for omissions, inaccuracies, and inconsistencies in field notations, and border notations are coordinated with adjacent mosaics.

FIG. 1.—Photographic copy at full scale of a portion of a field map, after notations made in the field have been inked in. The base is the aerial photographic mosaic. Scale: 1 inch equals 2000 feet.

HOLSTO

A field supervisor is responsible for planning and coordinating the work of the party. Two field men comprise a field crew; each crew using a car and working in the field as a unit separate from other crews. The two men alternate at driving and mapping so that maximum speed can be maintained without fatigue. Working thus, from 35 to 55 square miles can be covered per crew day, depending upon weather and road conditions, and the complexity of the landscape. To promote maximum uniformity and coordination of judgments, no two men work continuously together. Controversial points are discussed and agreed upon by the entire field party.

Office Procedures.—Finished mosaics are deposited in the central office. Because of wear consequent to handling, the originals are made available only for very special studies. For circulation and virtually all study purposes, the mosaics are reproduced photographically to a scale of one inch to two miles (Fig. 2). In some cases the reproductions are used as they are.

FIG. 2.—Portion of finished field sheet reduced to the scale 1 : 125,000, illustrating the form in which materials are made available for circulation and study purposes. Distributions of single items or combinations of items can be brought out by the use of colors. Transparent dyes are preferable since by that procedure the field data and landscape pattern can be retained (See Fig. 1, Table Two and text entitled "Office Procedures"). The following color scheme is adopted in the TVA to emphasize the five major classes of agricultural land:

CLASS I —Blue	CLASS IV —Yellow
CLASS II —Green	CLASS V —Red
CLASS III—Brown	Non-Agricultural—Uncolored

In other cases they are colored with transparent dyes to bring out the distribution of individual items or combinations of items.

Costs.—No definite statement can be made at this juncture concerning the total cost for carrying the work through to completion or the specific cost of any one phase of the work. It is estimated that the cost of bringing the mosaics through the stage at which field data are transcribed in ink will approximate $1.00 to $1.50 per square mile.[7] Additional costs will vary according to the number of reproductions made and the amount of color work done.

CONTRIBUTIONS

The unit area method of land classification as evolved contributes both to the field of geography and to the field of planning. In geography it affords another tool of investigation—one that partially fills, at least, the gap between methods of detailed field analysis and methods of reconnaissance. In planning, its use yields results that are vital to the development of an effective land plan.

In the Field of Geography.—Concerning the field of geography, the unit area method aims at a portrayal of the occupance pattern. This portrayal embraces two aspects of the pattern. One concerns the observable features of the pattern—the features that are expressed in the long fractions. The second concerns an appraisal of relative qualities—the appraisals that are expressed in the short fractions and in the Roman numerals. This portrayal of the occupance pattern is quantitative and complete in areal coverage. It retains considerable detail and a high degree of accuracy. At the same time, the size of the minimum units and the use of aerial mosaics permit a speed of operation heretofore impracticable in quantitative work employing the fractional code. The fact that this development of the unit area method and its application were motivated by the requirements of land planning do not detract from its ability to contribute to the field of geography.

In the Field of Land Planning.—The complexities of land planning, the fact that phases and procedures of land planning have not been fully formulated, and the fact that many basic data essential to land planning are still lacking make it impossible to ascertain the contributions of the unit area method to this field in great detail or with any considerable degree of finality. The contributions presented here constitute suggestions for which further consideration and experimentation are needed.

In the field of land planning the major contributions of the results yielded by the unit area method can be grouped into four broad categories as follows:

[7] This figure is lower than it would be on an independent undertaking since the work described here shares the cost of mosaics with other projects using prints from the same negatives.

a. in connection with specific developmental problems;
b. in connection with regional developmental programs;
c. in connection with the activities of local, state, and federal agencies; and
d. in connection with private enterprises such as manufacturing and commerce.

The following materials enumerate exemplary applications of the data yielded by the method to each of these categories.

1. Specific developmental problems.—Specific developmental problems in land planning pertain to such items as the construction of dams, the purchase of land for reservoir and reservoir protection areas, and assistance in resettling and re-employing population displaced by such land purchases. The unit area method can be used in the evaluation of such projects in three major respects: namely,

a. by measuring the amount and the quality of lands to be retired;
b. by discovering the location and extent of nearby areas suitable for resettlement; and
c. by discovering and appraising erosion conditions in reservoir drainage areas.

By locating and appraising the character of erosion conditions within reservoir drainage areas, the unit area method aids in revealing, among other things:

a. areas in which erosion control must be inaugurated to protect proposed reservoirs from damage by siltation;
b. the extent and nature of the erosion problem; and
c. the types of erosion control that might be put into effect.

By measuring the amounts and qualities of agricultural land in the neighborhood of proposed resorvoirs, the results of the unit area method held to determine, for example, the advisability of building for construction personnel a permanent town with an agricultural hinterland as contrasted with temporary accommodations.

2. Regional developmental programs.—One of the problems growing out of regional developmental programs pertains to the delimitation, understanding, and treatment of problem or critical areas—for example, areas characterized by maladjustment in land uses. The data provided by the unit area method render aid in four major respects:

a. in a more precise definition and delimitation of problem areas and conditions;
b. in determining the relative urgency of problems within each problem area;

c. in the understanding of the nature of the problems that occur and their significant underlying factors; and

d. in the selection of remedial measures.

3. Activities of local, state, and federal agencies.—One of the outstanding problems of governmental agencies is that of taxation. The data provided by the unit area method aid in the formulation of measures aimed at a sounder apportionment of taxes by indicating the present and potential relative ability of the land to support assessments. Another problem pertains to such matters as public works. The data provided by the unit area method lend material aid in the determination of areas in which such public works as highway, forest, erosion-control, and drainage projects are needed and the relative extent to which areas can make effective use of such projects.

4. Private manufactural and commercial enterprises.—With respect to private manufactural enterprises, the unit area method, among other things, aids in the discovery and appraisal of areas in which raw materials are available for manufactural uses, where foodstuffs can be produced for manufactural populations, and in which the location of manufactural enterprises is advisable or not advisable. From the viewpoint of commercial enterprises, the results of the unit area method reveal the varying quality of trade or market areas and suggest possibilities and policies with respect to it.

In indicating that the unit area method is an aid to the solution of the problems and to the programs noted above, it should be pointed out that a complete and satisfactory solution of these problems requires a wide variety of other materials such as complete soil data, topographic and geologic maps, climatic data, and population and income statistics. It should also be noted that the unit area method contributes more pertinently to some problems and programs than to others. The wide scope and the diversity of the contributions of the unit area method in the fields of geography and land planning are not due, it is believed, to mere fancy, but to the very nature of the method, since it provides a composite and quantitative depiction of certain pertinent geographic conditions. This manifold depiction permits manifold use.

Land Classification Section,
Tennessee Valley Authority,
Knoxville, Tenn.
December, 1935.

A Memoir of CURTIS FLETCHER MARBUT

HOMER LEROY SHANTZ

To see a new science develop, to help in its initiation, and to see it recognized throughout the world is the privilege of but few investigators. But to have been one of the important contributors and to die with still many years of work already planned ahead is truly the ideal of a scientific life.

Marbut began his scientific work as a geologist. The science of soils was practically unknown. Many chemists and physicists were interested in the materials from which soil is made, but study dealt with chemical content, physical or mechanical analysis, and with geological origin of the material. A soil in the modern sense had not yet been recognized. Following the work of Hilgard, Marbut soon began to correlate soils and vegetation. One more step, the correlation of soils with vegetation and climate, completed the modern point of view and enabled soil science to establish itself independent of geology, with which it had been too closely affiliated.

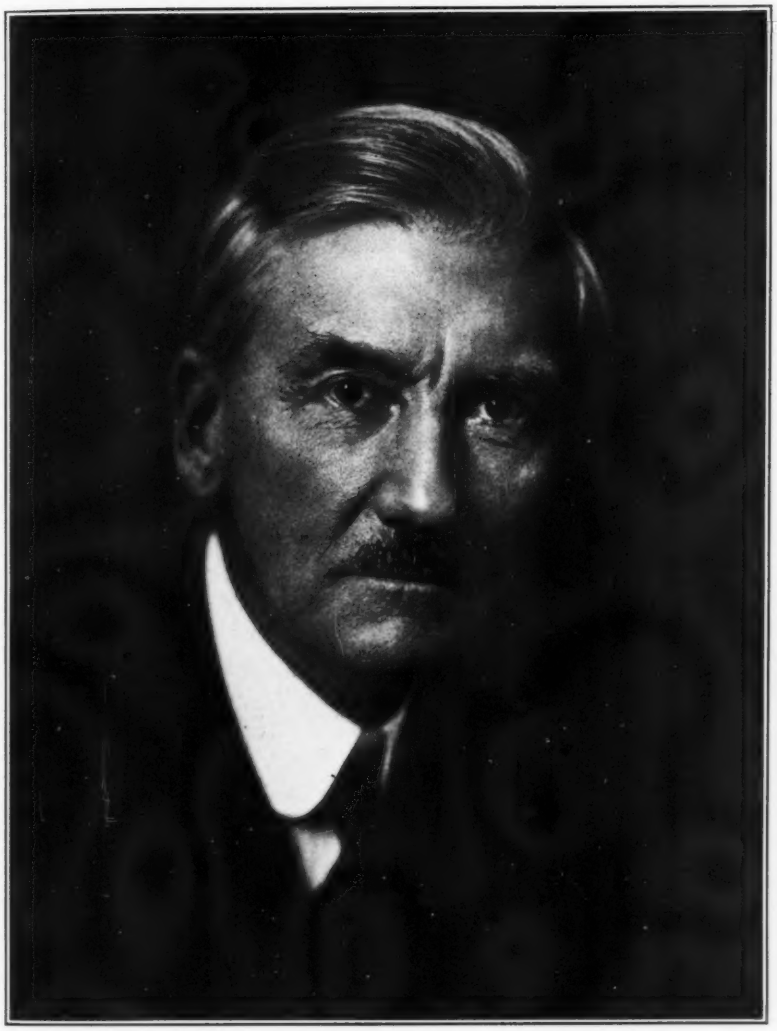
America with temperature belts running east and west and humidity belts running north and south presented a very complicated pattern and the recognition of close correlations with climate, vegetation and soils was extremely difficult. In Russia humidity and temperature run together, an ideal experimental situation. It is not surprising that the Russians first glimpsed the significance of the soil profile. Marbut immediately recognized in the work of Glinka a basic advance in soil science and set to work at once to translate the German into English. He knew no Russian at that time but set to work to learn that language, in order better to follow the works of Russian pedologists.

Our soils had been studied from a physical and mechanical and chemical and plant production point of view. Millions of acres had been surveyed and the soil types named. Marbut did not discard the good work already done but started slowly to interpret these types in terms of the new science. Naturally an indefatigable worker, he drove himself with constant field work. He succeeded in visualizing and holding in his memory thousands of observations and was ready to apply this wealth of knowledge at once to the interpretation of any observable condition. Thoroughly map-minded, he could trace at any time the line which had been previously observed in the field. A shovel, a pick, a soil auger, cloth sacks for samples, a bottle of acid, and a notebook were always at hand. A thoroughly optimistic attitude toward any difficult road or territory, willing at all times to sleep out

without food, and intent always on seeing as much as possible of the country, this was Marbut in the field, where he was constantly a most interesting traveling companion.

Together we pushed over much of the high plains, the grassland of the Canadian northwest and the deserts of California, Arizona, New Mexico, and Texas; of Colorado, Utah, and Wyoming and planned many a paper on the correlation of vegetation types and soil types. We were both interested in the lack of a direct correlation, in the fact that in the high plains the north and south soil belt swung east of the vegetative belt in the north and west in the south. Desert soils, especially the frothy surface soil in the shad scale area in Utah, interested him immensely. There was no thought of making a town for the night or of getting to a place to eat. Those trips were for the purpose of seeing the country, determining the soil profile and collecting samples for studies. There was never the moroseness which affects so many when hungry or when stuck in the bottom of Death Valley or in a sea of mud and water in a Nevada playa, changing tires in the mud of northern Canada or sleeping in a Russian hard carriage or trying to continue field work during a flood of the Pecos. His early life had inured him

C. F. Marbut examining desert pavement near Salome, Arizona, May 26, 1921.



CURTIS FLETCHER MARBUT, JULY 19, 1863–AUGUST 25, 1935.

to hardship and want and even the frugality of youth could not be easily overcome.

The life at the University of Missouri, where the faculty in the period 1905–1910 were an unusually sociable lot, meant much to him. Often he sang again the songs the men sang at their weekly or monthly get-togethers. His sense of humor was always evident and he enjoyed his busy life. He was always generous in discussions of debatable points; always willing to hear the other side. In all my experience I cannot remember a single misunderstanding or a single heated argument, either in the field or in scientific committees or meetings.

Curtis Fletcher Marbut, geologist, geographer, pedologist, was born in Lawrence County, Missouri, on July 19, 1863. His father, Nathaniel Thomas Marbut, was born in Tennessee in 1834 and Philip Marbut, his grandfather, was born probably in Newberry, South Carolina, in 1797. The family legend holds that the family had lived in Germany for a time after fleeing from Limousin, France, and that they later migrated to Charleston, South Carolina. His mother was Jane Browning of Scottish and English blood, her father having been a pioneer in Kentucky. She had a profound influence on her son Curtis who mentioned her repeatedly in his conversations. In an article by A. S. Alexander, Marbut is quoted as saying of his mother,* "In the welter of political conditions preceding the Civil War and in the period of intense religious emotions that swept backward communities in those trying times, she never lost her head. I owe more to her steady guidance in times of hesitation and doubt than to any other single influence." In discussing the effect of the tremendously emotional revival services held in the early days, Dr. Marbut once said that as the family climbed into the wagon to return home after such a meeting his mother said, "The God whom I serve is a God of order, not a God of chaos." His mother died in 1892 in her early fifties while his father died in his 74th year in 1909.

Those who have visited the Ozarks can visualize to some extent the conditions of pioneer families in that region. Dr. Marbut lived his early childhood working on the farm, and climbed about the Ozark hills, hunting, and fishing, when leisure permitted. He began his elementary education at the age of five from an itinerant teacher. Until he was seventeen he attended the little school through each short winter term of about four months. A small collection of books which his father had brought with him constituted his library. In 1881 at the age of seventeen he was granted his first certificate to teach in the district school. He taught there and boarded at home for several years, his salary being $150 for the winter term. This sum,

* *Better Crops with Plant Food*, vol. XX, no. 1, pp. 10–12; 23–26, April–May, 1935.

together with additional money which he obtained by feeding cattle, enabled him to enter the University of Missouri, where he was graduated with a Bachelor of Science degree in 1888, and as he says he was still a raw, uncouth country boy. He then taught school for a period of eight months and was appointed a member of the Missouri State Geological Survey in 1890.

On December 17, 1891, Dr. Marbut married Florence L. Martin, and they had a family of three sons and two daughters. Shortly after the birth of the third son Mrs. Marbut died, leaving to him the responsibility of bringing up the family of small children. The older daughter, Louise, assumed with him a large part of this responsibility and became for him a mother to the other children and one who contributed tremendously to his sense of social rest and security.

In 1893 he entered Harvard University and received a Master of Arts degree in geology in 1894. He remained another year to meet the residence requirement for a doctorate. At that time he wrote a thesis which was later published in the Missouri Geological Survey, but he did not receive his Ph.D. from Harvard since he was unable to return for his final examination.

He was instructor in Geology and Mineralogy in the University of Missouri from 1895–1897, assistant professor from 1897–99, and professor and curator of the museum of geology from 1899–1910. During the latter part of this period from 1905–1910 he was director of the Soil Survey of Missouri. It was during this time that he began to appreciate fully the importance of distinguishing between soils as such and mere pulverized material.

In 1909–1910 he became special agent for the United States Bureau of Soils and from that time to the day of his death he was Chief of the Division of Soils Survey.

In 1899–1900 he travelled over much of Europe chiefly on a bicycle and in 1919 through Central America, studying for the first time tropical soils. In 1923 and 1924 he studied the soils of the Amazon valley on an expedition organized by the Department of Commerce, which was studying rubber products, and with the aid of the American Geographical Society continued these studies into other parts of Brazil and Argentine. In 1930, aided by the American Geographical Society, he was enabled to study at first hand the soils of Russia.

In 1920 he was a delegate to the International Institute of Agriculture at Rome.

Dr. Marbut received many honors. The University of Missouri conferred on him the degree of LL.D. in 1916; Rutgers University conferred the degree of D.Sc. in 1930 on the occasion of the fiftieth anniversary of

the New Jersey State Experiment Station "as an international authority on soil geography." In the field of geography he was elected President of the Association of American Geographers in 1924, having been a member since 1904 when the Association was formed. He was a corresponding member of the American Geographical Society, and received the Cullum medal in February, 1930, from that society "for his geographical work on soils—the foothold of all things," along with such men as Peary, Nansen, Scott, Murray and Shackleton. He served as vice-president and councillor of the Association of American Geographers, was chairman of Section O of the Association for the Advancement of Science in 1926. He was also closely connected with the American Soil Survey Association.

At the first International Congress of Soil Science held in this country in 1927, Dr. Marbut was the outstanding figure and he has been at every meeting since that time. He was head of the International Commission on Genesis, Classification, Morphology, and Mapping of Soils, and presided over this commission at the Free city of Danzig in May, 1929. At the second International Congress of Soil Science in Leningrad in 1930, during the meetings at Moscow and during the long field trip with its many meetings he was constantly recognized as a leader.

Dr. Marbut was a member of the Geological Society of America, Phi Beta Kappa, Sigma Xi, Sigma Alpha Epsilon, and the Unitarian Church.

Although not directly engaged in educational work during his later years, he served as an inspiration to all students of soils and students of general geography in the discussion and presentation of papers and in his willingness to see and discuss matters with all visitors in his office in Washington, and to the many people who at various times had the opportunity to accompany him on field work. For a number of years he lectured for a month each year at the School of Geography at Clark University, and in the Graduate School of the United States Department of Agriculture, bringing inspiration and encouragement to a very large group of young geographers. While he was Chief of the Soil Survey that organization mapped about half of the land area of the United States, or nearly one billion acres. This great mass of detailed material enabled Professor Marbut to make a final contribution of the utmost importance, for he combined into a single comprehensive volume on the soils of the United States a distinct picture of the soil resources of the whole nation. This has been published by the Department of Agriculture as Part III of the Atlas of American Agriculture. No man in the world was so well qualified to analyze and condense this material.

To mention briefly his contributions to the field of geology and soils would require many pages of text. It would be an interesting task to trace through dozens of papers the development of the more complete idea of modern soil science. In the beginning his work extended and amplified

the great work of that greatest of all soil scientists prior to his time, Dr. E. W. Hilgard, who lived from 1833 to 1916. Dr. Hilgard's work laid the foundation in America for the further interpretation which has been given by Marbut. Hilgard's work up to the time that Marbut took charge of the Soil Survey had not sufficiently influenced that organization. Marbut, however, recognized that a soil is developed as a result of the interaction of climate and vegetation on the basic rock material and that over great belts soils will be similar notwithstanding the diversity of the basic material from which they have been developed.

At the University of Missouri he had already closely correlated soils and vegetations, for here you find the soils named from the type of vegetation which they support. Immediately recognizing the advance made by the Russians, he was able to take the accumulated materials reported by the then existing Soil Survey and give to this an interpretation in accordance with the new science. This was a matter which could not be accomplished rapidly, for public sentiment cannot easily be influenced and large numbers of men interested in soils and soils problems in the United States had approached the problem from the standpoint largely of physics, chemistry, and geology.

In 1918 the INQUIRY was established to assemble technical knowledge to be used by the American commission to negotiate paace following the World War. Intensive work on Africa resulted in THE VEGETATION AND SOILS OF AFRICA, published jointly by the National Research Council and the American Geographical Society.

Work on the soils of Africa was to Professor Marbut something of an intellectual adventure. It required considerable daring for him to indulge in an interpretation based on almost no direct factual material. Thousands and thousands of pages of material, the reports of expeditions made by geographers, geologists, ethnologists, and adventurers, resulted in almost nothing definite on the soils. The few samples which I was able to collect on a hurried trip were carefully studied and analyzed and formed the factual basis for the interpretation for the whole continent. Until the publication this year of the soil atlas of the United States, the material contained in this volume on Africa constituted the best assembled source for an understanding of the new science. As it stands it has served as a tremendous stimulus to younger workers in that field and has enabled them to approach their problem from the standpoint of the whole rather than details of local observation.

Working with Dr. Marbut on the vegetation and soils maps and particularly on the land classification maps, one was impressed again and again with his ability to recall isolated details and bring them to bear on any

particular discussion. This was as marked when dealing with summaries of literature as it was when dealing with thousands of facts observed in the field.

Marbut was chairman of Committee Number III, Land Inventories and Land Classification of the National Land-use Planning Committee, from 1931 to 1933. He stamped the work of this committee with the same genuine thoroughness shown in all of his scientific work. Defining land used for plant production as "the sum total of the factors of the geographic environment in which plants grow," they undertook the classification of different kinds of land on the basis of differences in capacity to grow plants and to arrange these units in such a way as to express gradation in this capacity. Since plants vary, it became a matter of rating the productivity of a given crop on a given spot, rating the most productive 10 and the least productive 1. Since the use of fertilizers had to be taken into account, many places would have a double rating. While this was not soil classification, it could be based largely on soil maps already prepared.

No man was so well prepared by training and experience, by natural ability and sound scientific approach, by singleness of purpose, by intellectual generosity, ability and willingness to do the hard work involved, by personality and scientific unselfishness which made cooperation easy, and by a willingness to undertake new languages and new tasks as Marbut to paint a clear picture of the soils of the whole world. His detailed knowledge of the soils of the United States exceeded that of any other man. The soils of Canada, Central America, Brazil and the Argentine, of Russia and Europe had been studied at first hand, and he read every account of soil survey or studies in order to fill out as much as possible this world picture.

Soils which had been under cultivation for centuries he believed held secrets of great scientific and practical value. And he often discussed the advisability of studying the soils of the Mediterranean and of China. One of his greatest ambitions was about to be realized when he set sail for Europe on his way to China. Some years ago he was somewhat disappointed when the Federal government decided to retain him in active service —for he had long looked forward to a chance to study the soils of the older communities in China. There is something tragic and something fine in the facts of his death. It came just at the beginning of what was for him his greatest opportunity. He was far from his friends, but received every care that modern medical science could give. A cold contracted in Washington, carried through a strenuous meeting of a committee over which he presided at the Fifth International Congress of Soil Science at Oxford, England, followed by trying days at Moscow and on the Trans-Siberian Railroad, resulted in his death from pneumonia at Harbin, Manchuria, on August 25, 1935, at the age of 71 years.

James Thorp was with him when he died, and he says in his letter to the family written on the day of Dr. Marbut's death:

"Mr. Adams, the Consul General, has suggested holding a memorial service here and we shall do this if possible. I am sure there will be a service at Peiping as Dr. Marbut's work is well known among the Chinese and he is held in very high esteem. The Chinese are accustomed to honoring old people, and one of Dr. Marbut's caliber who is still making great contributions to science and to human welfare at the time of his death is held in the greatest veneration. The term 'old man' or 'old gentleman' in Chinese is highly complimentary, and during recent years there has been much in the Chinese papers and periodicals regarding the famous 'old man' who was willing to come to China and give the youth of the country the benefit of his wide experience in his chosen field."

In an unsigned obituary in NATURE, September 7, 1935, the British point of view is expressed: "Marbut was not merely a shrewd observer, but also a man of great personal charm, and a singular power of capturing the affections of his colleagues. Tall, spare of build, alert and very active, with finely moulded features he was a striking figure in the various scientific conferences he attended, and he never failed to attract and hold the attention of his audiences."

On his old farm in Missouri in Barry County he had just completed a new house in which he planned to live and to write, for he had still much to contribute. There on October 26, 1935, his children and many friends, mostly from the University of Missouri, buried the Chinese urn which blended in color with the brown of the earth and the green of the vegetation.

He has made a great contribution to science and to human welfare and left only friends behind. His interest in the advance of knowledge was sincere and contained no element of selfishness or desire for personal aggrandizement. He never grew old, either mentally or physically, and had that rare ability of becoming increasingly efficient in his work up to the very end.

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